Scientia Horticulturae 193 (2015) 40–46

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Review

Texture phenotyping in fresh fleshy fruit

Loreto Contador, Paulina Shinya, Rodrigo Infante*

Departamento de Producción Agrícola, Universidad de Chile, Santiago 8820808, Chile

ARTICLE INFO

Article history:
Received 22 April 2015
Received in revised form 11 June 2015
Accepted 13 June 2015
Available online 9 July 2015

Keywords:
Textural properties
Descriptive analysis
Rheology
Fleshy fruit
Phenotyping

ABSTRACT

After the visual appearance, the texture of fresh fleshy fruit (FFF) is the most relevant factor that determines its acceptability. Therefore, texture should be a priority on fruit quality research. Sensory evaluation and rheological analysis have been the classical approaches used to study texture of foods. However, the relevance of texture on describing a FFF has normally been underestimated. The flesh firmness instead has been the most commonly assessed trait in most researches on fruit quality. Even though flesh firmness is a relevant component of texture, it does not help for segregating two samples possessing different textures. A deeper study of texture on FFF would allow us to discover and to annotate new phenotypic attributes. These data will help to reduce the imbalance between the scarce data obtained through traditional phenotyping and the huge amount of data obtained via high output genotyping platforms. The aim of this review was to analyze critically the literature concerning sensory evaluation and the rheological studies on FFF, looking to reach a better comprehension of texture, and consequently to reach a deeper characterization of phenotypes in genetic and descriptive studies on FFF species.

Contents

1. Introduction

Texture in fresh fleshy fruit (FFF) is one of the primary attributes determining consumer preference (Bonnin and Lahaye, 2013; Tunick, 2011). It is important for growers and industry stakeholders (Redgwell and Fischer, 2002), and one component of texture—flesh firmness—is the parameter commonly used along the entire production chain to determine the harvest time (Infante, 2012), and to monitor maturity during postharvest (Zhang et al., 2010). Texture is a sensory property perceived through sight, hearing, and touch; likely it is the most important sensory attribute linked to the structure of food (Ross, 2009; Szczesniak, 2002). Traditional food texture has been measured through instrumental analysis and sensory evaluation (Chen and Opara, 2013; Ross, 2009), and both approaches provide valuable information for its comprehensive understanding. Thus, the aim of this review was to analyze the sensory and rheological approaches for reaching a deeper characterization of phenotypes on genetic and descriptive studies on FFF species.

2. Texture in foods

In addition to nutritional value, the main attributes that define the quality of a food are visual appearance, flavor, aroma, and texture (Bourne, 2002). Texture, conceived of as a fundamental food organoleptic property, has gained greater importance among researchers worldwide (Bourne, 2002). Initially, simple instrument

* *Corresponding author.
E-mail addresses: lcontador@uchile.cl (L. Contador), pshinyam@u.uchile.cl (P. Shinya), roroinfante@gmail.com (R. Infante).

http://dx.doi.org/10.1016/j.scienta.2015.06.025
0304-4238/

and sensory measurements were performed to define the characteristics of a food's texture (Szczesniak, 2002). The literature includes an extensive discussion of how texture is linked to the microstructure of food, along with the rheological properties and sensory perceptions observed by consumers. People perceive subtle differences in texture, and then use those slight differences as a determining factor for the acceptability of a food product (Shewfelt, 1999). Here, the perceived texture of a food sits largely at a subconscious level, but when a defect is detected, this can become a cause for rejection (Szczesniak and Kahn, 1971). In fact, while taste is usually the main sensory attribute that defines the acceptability of a food, texture is often cited as the reason for its disapproval (Cardello, 1996).

The most accepted definition of food texture is "*a sensory and functional manifestation of the structural, mechanical and surface properties of foods detected through the senses of vision, hearing, touch and kinesthetics*" (Szczesniak, 2002). Moreover, texture is characterized by five main features (Bourne, 2002; Szczesniak, 2002): (1) only humans can perceive and describe it; (2) it is a multi-parameter attribute; (3) it derives from the structure of the food (molecular, microscopic, or macroscopic); (4) it is detected by several senses, the most important being the sense of touch—including pressure—which is unrelated to taste and smell; and (5) it is associated with rheology, or the physical properties, understood through measurements of mass, distance, and time.

3. Sensory evaluation of texture

At present, the main objective of the FFF industry is to improve product quality to meet the growing expectations of consumers (Bonany et al., 2013; Gunden and Thomas, 2012; Iglesias and Echeverria, 2009; Ji et al., 2013). Here, sensory analysis, which is the use of human judgment through the senses, remains an irreplaceable method. Sensory analysis is highly valued by companies and researchers (Ares and Jaeger, 2013; Iannario et al., 2012). The information supplied by sensory analysis can be used to help market a particular product by understanding the tastes and preferences of consumers, especially when correlated with instrumental data (Iannario et al., 2012; Valentin et al., 2012).

Unlike other sensory attributes, such as taste and color, the perception of texture involves three senses working in concert: touch, sight, and sound (Szczesniak, 2002). Most of the sensations associated with texture occur when food is handled, chewed, and moved among the receptors of the mouth, which also involves the skull's muscles and connective tissue (Cakir et al., 2012; Chen, 2009; Engelen and Van Der Bilt, 2008; Foegeding et al., 2011; Szczesniak, 2002). However, a food's visual appearance provides certain information to the consumer, as well. For example, the color of the skin of a fruit can be an index of maturity, and, therefore, of firmness. Further, pressing a piece of fruit lightly by hand, cutting it with a knife, or penetrating it with a fork can be used to infer flesh firmness, crispness, and fibrousness (Engelen and Van Der Bilt, 2008; Guinard and Mazzucchelli, 1996; Wilkinson et al., 2000).

Sensory evaluations may be hedonic—as when ordinary people rate how much they either like or dislike a particular food—or they may be analytical—based on the judgments of people who are ad-hoc trained to identify, describe, and measure the characteristics of a given food (Lawless and Heymann, 2010; Meilgaard et al., 2010). In the latter case, to facilitate the training process, a classification system of three categories was developed for the texture dimension (Szczesniak, 1963). These categories are: (1) mechanics, which in turn, is divided into five basic parameters (i.e., hardness, cohesiveness, viscosity, elasticity, and adhesion) and three secondary parameters (i.e., brittleness, chewiness, and gumminess); (2) geometric, which is related to the size, shape, and orientation; and (3) composition, which is primarily related to the moisture and fat content of a food.

The methodology used most often to analyze the texture of food is descriptive analysis (DA), which is closely linked with quantitative descriptive analysis (QDA) (Valentin et al., 2012). DA has three main steps: lexical development, the training of panelists to standardize concepts, and the quantification of attributes based on an intensity scale (Meilgaard et al., 2010; Valentin et al., 2012). Lexicons are standardized vocabularies that facilitate communication across diverse audiences. Ideally, a lexicon is based on a list of reference products, all associated terminology, and the definitions and references for each attribute (Lawless and Civille, 2013). The lexicon used in texture studies are so varied that there have been studies examining the differences between languages, including work analyzing English and Finnish (Lawless et al., 1997), and differences between English, French, Japanese, and Chinese (Nishinari et al., 2008). One study (Hayakawa et al., 2013) reports 445 different terms in the Japanese language to describe the components of texture.

Here, some of the studies that stand out explore specific descriptions of red apple (Swahn et al., 2010), tomato (Hongsoongnern and Chambers, 2008), and mango (Suwonsichon et al., 2012). Most studies that address the sensory texture of FFF include the attributes of pulp "firmness" and "hardness" (Arana et al., 2007; Barreiro et al., 1998; Cano-Salazar et al., 2013; Chauvin et al., 2010; Galvez-Lopez et al., 2012; Harker et al., 2002; Maury et al., 2009; Mehinagic et al., 2004; Valente et al., 2011); there is, in fact, some consensus of these definitions, which relate to the force required to completely break the sample with molar teeth (Chauvin et al., 2010; Jaeger et al., 2003; Valente et al., 2011).

In addition, in FFF studies special attention has been paid to the terms "crispness" and "crunchiness" (Fillion and Kilcast, 2002; Harker et al., 2010). Both terms are associated with the sound food produces in the mouth, and both refer to its fracture properties (Luyten et al., 2004; Van Vliet and Primo-Martin, 2011; Vickers, 1982) because foods that have these attributes are essentially non-compliant, and therefore, relatively easy to break (Kim et al., 2012; Luyten et al., 2004; Van Vliet and Primo-Martin, 2011). It is generally accepted that "crispness" is defined by the first bite, while "crunchiness" is produced by a series of fracture events occurring during mastication (Fillion and Kilcast, 2002; Luyten et al., 2004). Yet, each term has more than one meaning, and thus it is difficult to define both precisely (Chauvin et al., 2008; Roudaut et al., 2002). In food studies, these terms have mainly been described with apple (Allan-Wojtas et al., 2003; Brookfield et al., 2011; Costa et al., 2011; Chauvin et al., 2010; De Belie et al., 2002; Gatti et al., 2011; Oraguzie et al., 2009; Zdunek et al., 2010, 2011), as apple is a fruit that is well-known and appreciated for its crunchy texture. In addition, these descriptors have been used in studies on some nut species, for instance, almond (Civille et al., 2010; Varela et al., 2006; Contador et al., 2015a) and pecan (Ocón et al., 1995). To a lesser extent, the terms "crispness" and "crunchiness" have also been used in studies on other FFF as pear (Buchner et al., 2011; Chauvin et al., 2010; Jaeger et al., 2003), mango (Valente et al., 2011), and peach (Cano-Salazar et al., 2013).

Another descriptor used specifically for those fruit species in which pulp softens during ripening is "melting," which is associated with the way in which the sample disintegrates in the mouth, often without chewing (Bengtsson et al., 2011). "Melting" has been identified as the main attribute of texture in both banana (Bugaud et al., 2013, 2011) and mango (Suwonsichon et al., 2012; Valente et al., 2011). In addition, "melting" has also been a main attribute of peach, in which genotypes are segregated according to the Mendelian trait in melting and non-melting (M/NM) (Infante et al., 2008). A similar descriptor is "easy breakdown," which is defined as the number of chews required to swallow the sample.